A first classification of the zoogeomorphological activity and impacts by large mammals in National Parks, South Africa

Cecilia Engvall
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1. INTRODUCTION

Animals move through landscape impacting on their paths in various ways. Such impacts can be footprints after trampling, degradation of plants through grazing and movement of soil by geophagy and wallowing just to name a few. These animal activities have been studied previously by for example Butler and Haynes and it is evident that these natural activities have various impacts on landscape. The important factor is what kind of impacts these activities have, and to what extent. Direct impacts are mostly visible in the nature and sometimes discussed but not classified and assessed in current literature. Explanations for why and how these impacts occur are more widespread in the areas of biology and ecology, than in physical geography and geology. This study will be conducted through Google Earth and web-camera observations, with the aim to assess, define and classify the activities and impacts in the areas where selected animals have their natural habitat.

The activities concerned will be zoogeomorphological, defined by how animals change their surroundings through natural behavior. Focus is therefore not on the behavior per se, but specifically the occurrence of change in landscape as a result of activities. The observations will be made possible by observing three different web-cameras, located at three different areas in South Africa. Addo Elephant Park 72 kilometers west of Port Elizabeth,1 Tembe in the north-east corner of South Africa, on the border of Zululand and Mozambique which is a part of Kruger National Park and Orpen which is a so called rest camp in Kruger National Park. These web-camera observations will aid in a classification of activities and impacts. It will also help defining the span of these activities and impacts. Special attention will be paid to elephants and other large mammals because their size will exacerbate the impacts of the activities performed.

The aim of this study is: To develop a classification of potential patterns in zoogeomorphological large mammal activity, (with extra focus on African elephants) and, to describe impacts of these activities on landscape through Google Earth and web-camera observations.

Three objectives have been determined:

- Develop a theoretical basis on zoogeomorphological activity and impact at three observation sites in South African national parks
- Create a first assessment and map the physical impacts on landscape via Google Earth
- Classify visible zoogeomorphological impacts by observed activities on landscape through web-camera observations

1 www.addopark.com 2013-01-02: 12:31
2. PREVIOUS RESEARCH

When comparing various kinds of literature it is valuable to understand the differences in scope and chosen areas of interest. To define terms, as the terms below, there are aspects that are sometimes discussed by different authors and sometimes not. A good example is the use of the term biogeomorphology, which is the basis for zoogeomorphology. Larissa Naylor et al\(^2\) discuss the use of the term biogeomorphology as something that needs to be used more often. She does not bring forth the importance of larger mammals. Instead she defines biogeomorphological impacts on a micro level.\(^3\) She does also write about zoogeomorphology as a term considered less valuable, mostly used by other authors in titles\(^4\). She also refers back to Butler where the term zoogeomorphology is explained thoroughly\(^5\). Butler’s definition of zoogeomorphology will be explained below.

2.1 Classification of important terms

In this section following terms are classified: geography, geomorphology, biogeomorphology and zoogeomorphology. The order of terms depends on where this research is rooted. This study is conducted with a geographical point of view. All these terms are related, and understanding them is important because they will be frequently used throughout this study. Geography will be the first term classified, followed by geomorphology, an area of study focusing on landscape processes, i.e. how landforms develop through time. After this biogeomorphology will be explained, here an important factor is the ‘bio’- i.e. how organisms alter landforms. Lastly, zoogeomorphology will be classified, here the important factor is the word ‘zoo’- which means animal impact on landform processes, or animals as landform processes.

Geography can be defined as a sort of gateway between various perspectives of disciplines trying to explain and determine landscape and landscape processes with human involvement.\(^6\) Physical geographers have dealt with the interactions between the different disciplines concerning the world we live in for a long time.\(^7\) These are now considered to be systems that are interlinked with each other. According to Rogers et al\(^8\) the study of these disciplines with a certain view is of importance to understand links between various perspectives of disciplines.\(^9\) Rogers et al writes that a geographical perspective when conducting a study will not only provide the base for a vision spanning from past to present and to the future, it will also have these links in mind and therefore creating studies that will cover a broader span between other disciplines\(^10\).

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\(^2\) Naylor et al 2001, p. 15
\(^3\) Ibid, p.15
\(^4\) Ibid, p.15
\(^5\) Ibid, p.15
\(^6\) “own observations”
\(^7\) Rogers et al 1992, p. 3
\(^8\) Ibid, p.3
\(^9\) Ibid, p.4
\(^10\) Ibid, p. 4
Geomorphology is the study of landforms and land processes i.e. how the landscape is built up and with what kind of sediment.\textsuperscript{11} Geomorphology, as described by David Butler, is the study of landforms and landform processes as well as explanations on their current form and shape. This is done, by Butler, by a description of erosion, transportation and sediment deposition.\textsuperscript{12} Importantly, geomorphologists focus on the various time aspects in landform processes, keeping a thought of past, present and future in mind when conducting research and assembling evidence.\textsuperscript{13}

Biogeomorphology describes the interactions between animals and their non-biotic environment.\textsuperscript{14} Biogeomorphology takes all kinds of animals, all over the world, into consideration. Heather Viles describes a current change amongst studies about geomorphology and ecology towards a more biogeomorphical view, where more interactions between various subjects have been of interest.\textsuperscript{15} Butler writes that in biogeomorphology the activities of animals are sometimes described as biotic, which means direct, or abiotic, which means indirect.\textsuperscript{16} This was already discussed by D.S.G Thomas in 1988.\textsuperscript{17} Biotic also means that the activities alter the structure of the community in which they live, i.e. when mammals wallow and graze, the ground cover can be reduced or totally removed which exacerbates the erosion rate.\textsuperscript{18} Abiotic refers to all the activities where the presence of animals creates structure and amplifies landscape processes.\textsuperscript{19} This can be, just to name a few, when animals wallow, tramples or drinks from waterholes.\textsuperscript{20} Other factors are described in the next section of this paper.

As defined by Butler, the discipline “zoogeomorphology” explains, quantifies and assess the interaction and geomorphological effects of animals on landscape\textsuperscript{21}, i.e. how activities and impacts of animals can be seen in the landscape through time. This also provides the foundation for further studies about the impacts in the future. An important detail is that human-induced changes should not be confused with the activities and impacts by animals. Conducted studies should instead be focused on animal induced changes in environments with as little influence by humans as possible, although this is knowingly difficult.\textsuperscript{22}

Zoogeomorphology is a term not excessively used in Geography, if used at all, although the impacts of animal activities are significant and sometimes easy to identify. The chief difficulty is that these activities and impacts have not been thoroughly studied and thus not classified and assessed. This means that no real conclusion can be drawn about the importance of studying animals from a geographical viewpoint. Human activities are studied in multiple ways, but animals alter landscape and landscape processes as well.

\textsuperscript{11} Corenblit et al 2011, p. 310
\textsuperscript{12} Butler 1995 p.1
\textsuperscript{13} Ibid, p. 1
\textsuperscript{14} “own observations”
\textsuperscript{15} Viles 1988, p.2
\textsuperscript{16} Butler 1995, p. 82
\textsuperscript{17} D.S.G Thomas in Viles 1988, p. 204-205
\textsuperscript{18} Butler 1995, p.82
\textsuperscript{19} Ibid, p.82
\textsuperscript{20} Butler C.F Sawyer 2006 p. 2
\textsuperscript{21} Butler, 1995, p.6
\textsuperscript{22} Ibid, p. 6
2.2 Classification of known activities and their impacts

This section will focus on a classification of various activities and their impacts. This is done to ensure that activities seen on web-cameras can be defined and classified the same. To classify activities will provide a base for any study such as this to be performed the same way and thus help further research. Activities classified are: trampling, wallowing, grazing, uprooting, geophagy, digging and mourning. As a start, findings from previous literature, where zoogeomorphological impacts can be read, will be conferred.

Observations have been made where mammals alter the landscape through normal basic behavioral activities. An example of this is discussed by Butler, “in order to drink, mammals may trample the landscape around a waterhole”. He continues by stating that the trampling leads to a change in the fringes around the waterhole, and it is possible that the compacted soil around the waterhole attracts other animals. Some impacts that activities of animals have on landscape can be larger than others. Where animals migrate, the paths to and from, may cause trails that compacts soil and makes it harder, or impossible, for vegetation to grow. Gary Haynes discusses these trails and how humans have later used these to plan the structure and placing of roads. Thus the impacts animals have on landscape is something that has a continuum over many years. Gary Haynes states that elephant impact on landscape may be visible for thousands of years. Another example of trails being a feature that last for many years, is a description on the information page on the webpage for Tembe National Park, were elephants have created “ancient pathways” which can be followed with 4x4 wheel cars.

* Trampling – is the act of walking, running, stampeding and creating paths by animals on the ground, via trampling moving patterns can be traced and quantified. Trampling occurs in all groups of animals and it has no correlation to the size of the animal itself. Furthermore, it is also an act of trampling when an animal walks by itself, because it is the act of travelling from one location to another which is trampling. Elephants are known to migrate between different areas during the year. Haynes explains that this is because of seasonal changes- When the grass dries out during summer, elephants must travel to areas with more woody vegetation to get to the twigs and leaves. The impacts of trampling on landscape can be both direct and indirect, especially when it causes erosion. Trampling around the edges of water sources can directly alter landscape from the edges being damaged. This could make the soil looser or making the water source, like a waterhole or a stream, larger. Indirect impacts are when ground cover is completely rubbed off or eaten. According to Butler the impacts of trampling is most visible to a greater extent because it alters bigger “patches” of landscape.

* Wallowing - is the kind of activity when animals stay in one place, gathering in herds or by themselves. An example of wallowing is when warthogs and elephants lie down in mud

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23 Butler 1995, p. 82
24 Ibid, p.82
25 Haynes 2011, p.99
26 Ibid, p.99
27 Ibid, p.103
28 www.tembe.co.za 2013-01-03 14:20
29 “own observations”
30 Haynes 2011, p.101
31 Ibid, p. 101
32 Butler 1995, p.83
holes and rub themselves in the mud. Some mammals, like elephants, use rock surfaces or wooden stubs to scratch themselves sometimes polishing the surface completely. These activities occur frequently. Examples of direct impacts from wallowing are for example the polished surfaces of rock walls from where animals have scratched themselves or eaten soil. Indirect impacts are when animals lie down in the mud and later get up, removing mud from the wallow, which later, when it dries, will fall off.

* Grazing - to eat vegetation, on ground level or up in trees. When animals pick their areas for grazing, many different variables are considered. It is found by Valeix et al that smaller herbivores choose to graze in areas which are showing impacts of elephant grazing, if the grazing by elephants has not been too intense, so that no new shoots have grown. Larger mammals, as the giraffe, also selects areas where there have been elephants impacting on the landscape, but according to Valeix et al this is more due to the fact that elephants uproot trees and therefore enhances visibility. Valeix et al suggests that with a decrease in trees, other herbivores can feel more secure while grazing and therefore the impacts by elephants on landscape help to increase visibility. When a woody area has been under pressure from grazing by elephants it might change the whole structure. Elephants can strip all branches and twigs of trees, sometimes they even knock trees over to get to the upper branches.

* Uprooting - especially elephants are known to uproot trees, either to get to the leaves, to play, in anger or just for the sake of it. Direct impacts of uprooting are visibly impossible to miss, because larger mammals like elephants can destroy large patches of land when they uproot trees. Indirect impacts are when the uprooting of trees in turn helps other animals. As mentioned above, giraffes prefer to graze in more open environments.

Here, we show that elephants can be considered ecosystem engineers because they modify food availability as well as visibility, hence lower the predation risk in the habitats of other herbivores. Gary Haynes uses the term ecosystem engineers to define elephant behavior. For example he discusses elephants stripping bark of trees and digging in the soil with their trunks. This behavior alters the landscape and it also influences their surroundings, and the animals living in the same habitat. Therefore they are ecosystem engineers. According to Jachmann and Croes woodlands can be completely destroyed by browsing elephants.

* Geophagy - when animals eat soil or rocks to get to minerals. Some animals gather at special places to lick of stone surfaces, these spots are called saltlicks, it can be seen as a natural version of the salt licks that are given to cows. Butler defines geophagy as “earth

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33 Haynes 2011, p. 101
34 Ibid, p. 101
35 Valeix et al, 2011, p. 910
36 Ibid, p. 910
37 Haynes 2011, p.101
38 Ibid, p. 101
39 Valeix et al 2011, p. 908
40 Haynes 2011, p.100
41 Ibid, p.101
42 Jachmann and Croes 1990, p. 22
consumption”43 which is a perfect way to sum up what geophagy actually entails. Animals may even travel vast distances to get to specific spots where they can get to a certain mineral and they keep coming back to the same location.44

Direct impacts of geophagy are when soil or rocks are actively removed or eaten thus altering the spot where it is taken from. This creates visible cavities in the landscape, especially when bigger animals are the ones removing the soil.

* Digging – Mammals dig for soil, roots and plants, but also to create resting spots, shade and to protect from heavy rainfall.45 Larger mammals sometimes paw at the ground, i.e. scrape the ground to get to roots and forbs. Other smaller animals sometimes dig tunnels to get to the same food source.46

Gary Haynes gives an example of when African warthogs dig out holes for nighttime to protect from predators. This is often done in already existing diggings created by other animals, like antbears.47 This shows both an indirect landscape impact because the excavations are often already there, although the use of them changes between different species of animals. But when digging is done at new locations it turns into a direct impact because new holes and borrows are created.

* Mourning – especially elephants are known to mourn their dead. This behavior and activities are mentioned by Haynes when confirmed that elephants sometimes re-arrange the bones of dead elephants when they come across old bones at death sites.48

2.3 Land use – changes in farming – sustainability
Sustainability is defined as the concept of usage without endangering a future with the same possibilities.49 Sustainability is a core subject for this study although not extensively discussed. This is because a sustainable future for African animals is a topic often discussed when reading literature about land use and farming. It is a key concept in all literature read for this essay because the essay is focused on wildlife and reserves.

A sustainable future for African animals is of outmost importance, especially because so many animals are endangered and near extinction.50 It is also important for the people living in regions and countries who depend on these animals, not only for food but also as a source of income, via different kinds of tourism, game reserves and national parks.

The former role of farms and land use in South Africa, consisting of for example sheep farming, has changed into many private game reserves where wild animals are used.51 Not only have the way of farming changed. There has also been a new focus on preserving the natural sources of income. In South Africa this means an upswing for several kinds of

43 Butler 1995, p. 43  
44 Ibid, p. 84  
45 Haynes 2011 p. 99  
46 Hamandawana 2011, p. 2  
47 Haynes 2011 p.99  
48 Ibid, p. 102  
49 “own observations”  
50 “own observations”  
tourism, such as tourism for hunting, photography and safaris. Tourism, when done properly can be a sustainable income for many people in South Africa and it can provide jobs for people from different levels of society. The importance of tourism for a sustainable economic growth is not always considered a possibility or even positively. Hottola argues that tourism may be used as a strategy for decision-makers to look decisive, although they are not actually providing anything of worth on the matter. He also discusses the difficulties in harnessing any outcomes of tourism. The people who own land around certain areas like reserves and parks, sometimes lack knowledge and information as well as evidence about the importance of biodiversity. This hinders sustainable decisions about land use. Moreover, Dikgang and Muchapondwa define the current state of the decisions already made in this quote below:

“It is clear from the way land restitution claims within protected areas have been handled so far in South Africa that sustainability and biodiversity conservation are critically important”

It is of importance to note that this is concerning sustainable use of land, and it should be encouraged by constantly showing evidence of the positive outcomes. The differences in the land use activities also have an effect on the conservation of the animal reserves in South Africa, in terms of land management and sustainability as discussed in the survey by Dikgang and Muchapondwa. The difference in preferences of land use depends on economic and conservational aims, where land use is affected by the preferences in various ways. Some economic factors include the use of land for cattle grazing, in comparison to land use for conservation factors where the aim is to preserve the flora and fauna, which is the more sustainable land use alternative. Land adjacent to game reserves depends greatly on the land use preferences of surrounding land owners/users. These areas around game reserves are used to provide livelihoods for the owner. Land where animals should be protected and not exploited, when surrounded by land where people must find a way to make a living, makes it easy for people living in these surrounding areas to find ways to use animals instead. This can be done in a sustainable and humane way if guided and governed properly. Sadly that is not always the case.

The various methods for managing different kinds of wildlife are sometimes not agreed on. These methods may include fencing and lethal control. Fencing has proved to be vital in conservation, of for example elephants, which as described by Kerley et al “do not persist outside conservation areas”. People working amongst animals are often entangled in ethical discussions. This in combination with the difficulty to actually carry out sustainable wildlife management, shows the importance of clearly stating the importance of the work that is put

53 Hottola P, 2009, p. 1
54 Dikgang & Muchapondwa 2012 p.8
55 Ibid, p. 8
56 Ibid, p. 7
57 Ibid, p. 8
58 Ibid, p. 9
59 Kerley et al 2003 p. 174
60 Dandy et al 2011, p. 705
down in conservational parks, and other areas. It is also important to make people involved in working sustainably, for example through consultation, land-ownership and through media thus making different people feel interested and important.  

**2.4 Short facts about game reserves and elephants in South Africa**

Game reserves are parks and other areas where there is a focus on animal presence, either for preservation or for tourism or hunting. In this section there will also be a short description of apartheid because it was after the abolishment of apartheid where game reserves started to gain importance throughout the South African society, as a means for income independent on the receiver.

Animal welfare according to Harrop is founded on ethic decisions, instead of decisions made from scientific suggestions. There is evidence for a rapid shrinking of areas concerned as ‘wild’. Many species are forced into areas that are limited geographically, these areas are sometimes considered as a positively controlled environment. Harrop continues with describing the current unwillingness to treat animal welfare as serious as it should with the following quote:

“There has been a general unwillingness to extend welfare protection to animals living in the wild and, once the work of conservation has been traditionally concentrated on in situ strategies with animals living in their natural ranges and habitats...”

In this quote it is evident that there are issues with the current animal welfare discussion, more variables have been brought forth considering animal suffering. Harrop also discusses how areas seen to be protected actually can be a negative influence where they are destructive for larger mammals.

Following is a short introduction to apartheid, important for the following section. In 1948, the all-white government in South Africa began to enforce racial segregation. That meant that people were divided in different races depending on skin-color. The races were supposed to be separate from each other in all aspects of society, even though there was much debate inside South Africa as well as the rest of the world. Apartheid was not abolished until 1991. Some areas in South Africa has since the abolishment of apartheid been governed by the indigenous land owners. These areas of land are called Homelands and they are according to Keley et al characterized by a high amount of cattle grazing, soil erosion and unsustainable wood harvesting.

Authors like Kerley et al writes that areas that are governed sustainably and controlled at a national or provincial level can be divided into statutory reserves and non-statutory reserves. The difference between statutory and non-statutory reserves is that the statutory reserves have

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61 Dandy et al, 2011, p.705  
62 Harrop 2011, p.448  
63 Ibid, p.449  
64 Ibid. p.443  
65 Ibid, p. 452  
66 Apartheid: www.history.com/www.levandehistoria.se  
67 Kerley et al 2003, p. 171
a more secure legal and institutional structure. The parks in this study are so called statutory reserves. According to Rouget et al. discussed by Kerley et al. “22% of the Cape Floristic Region, which is a region stretching through the middle of South Africa, is conserved in either statutory or non-statutory reserves”.

Another variation of parks with conservational purposes is called “contractual parks” which is owned by private persons, the government or a whole community collaborating with each other, governed by a “Joint Management Board” also known as JMB. These collaboratively owned parks are of various sizes and exist in all of South Africa.

Elephants are a class of mega-herbivores that are especially significant when considering sustainable floral and faunal conservation methods. Animals like elephants and also rhinoceroses attract tourists and investments that can be used to expand the economy in countries like South Africa, thus having a positive impact on other animals as well.

Bindi Thomas et al describe elephant herds to be matriarchal where every single group is governed by a strong matriarch. These matriarchs are often related to each other, and when many groups get together it is called a “bond group”.

A suggestion reoccurring in literature concerning animal reserves and sustainable futures is that the attitudes concerning wildlife management and sustainable conservation methods changes depending on the people that are part of the discussion. This varies systematically in the social spectrum. Dandy et al brings forth one explanation for this which is that it is the relationships between humans and animals that influence the attitudes. The special structure is depending on how much interaction people has had with different animals, because this contributes greatly to knowledge of various methods of conservation, as well as the perceived importance of sustainable methods. It is also stated that there is a significant similarity in the experience of animals depending on certain positions people have in their social groups in society.

2.5 Parks and web camera observation sites

In this section information about the web-camera observation sites will be presented, this is to enhance the understanding of animal movement and to define where the sites are located in South Africa. Furthermore, information about the parks will be presented.

Addo Elephant National Park covers 1800000 hectares and is the third largest national park in South Africa, located at the coastline between Port Elizabeth and Capetown. Addo inhabits various species such as the so-called “Big Five” i.e. African Elephants, Rhinoceroses, Cape Buffalos, Lions and Leopards. The park is open to the public for photo-tourism and safaris. Addo is a refuge for 550 elephants among other species. The web camera location is

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68 Kerley et al, 2003, p. 171
69 Reid et al in Dikgang & Muchapondwa, 2012, p. 8
70 Kerley et al 2003, p. 174
71 Thomas et al 2008, p.6-7
72 Dandy et al 2012, p. 706
73 Ibid, p.706
74 Sanparks website: (Addo Elephant Park) www.sanparks.org/parks/addo
75 Sanparks website: www.sanparks.org/parks/org
defined by a bushy landscape with a watering hole in the center and there are also areas for grazing with grass cover.\footnote{“own observations”}

Orpen is located in the north-east part of South Africa. The thickness of vegetation here differs a little from Addo, the ground cover contains of low bushes and fewer trees. According to the Kruger National Park website,\footnote{Kruger National Park website: www.krugerpark.com/jh-orpen.html 2013-01-03 12:05} Orpen is a rest camp of circa 24500 hectares. It is named after a family called Orpen which donated land to the park in the late 1930s. Orpen rest camp in Kruger National Park offers lodges for accommodation and serves as an entrance for this specific part of the park. It also offers sightings of carnivores like cheetahs, lions and leopards.\footnote{Kruger National Park, www.krugerpark.co.za/Kruger_National_Park} The Orpen family also sponsored boreholes to create waterholes for animals. Orpen waterhole is such a borehole, which is evident when observing the shape of the waterhole.\footnote{Ibid, www.krugerpark.com/jh-orpen.html 2013-01-03 12:05} The watering hole in Orpen has an elliptical form with narrow banks which often overflows when animals wade into the waterhole.\footnote{“own observations”}

Tembe National Park houses various kinds of animals much similar to Addo. Tembe watering hole is larger than Addo and Orpen and it is surrounded by higher trees and bushes. It is also surrounded by wallows where elephants often gather.

The web camera observation sites are all located near waterholes and wallows because most animals gather around these areas. The vegetation is similar on all three sites, with some difference in tree cover, as well as amount of bushes. Especially elephants are known to roam in areas located within 1 km of water, where there is also a larger impact on vegetation.\footnote{Valeix et al, 2011, p. 906} The cameras are owned by the parks themselves and are also managed by the park and therefore they cannot be moved to perfectly fit the purposes of this specific study.

### 3. METHOD

This paper aims to classify the activities of large mammals as well as the impacts of these activities. This is done through a thoroughly performed literature study which will be the base for further investigation through web camera observations. Web cameras show animal activity without human interference, therefore it is a trustworthy method to be able to visualize what has been read in previous literature. Observing is also a way to determine what activities are performed, and it gives a dimension to the research which cannot be achieved through only reading previous studies. To be able to achieve said aims some aspects have been chosen to be ignored and other to be closely looked at. Larger mammals have larger impacts, therefore they are more visible through web-camera observations. Birds, amphibians and reptiles are not considered in this study at all, because their impacts are different to the ones that can be seen from larger mammals. Larger mammals also travel on the ground thus making the impact on landscape vast.

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76 “own observations”

77 Kruger National Park website: www.krugerpark.com/jh-orpen.html 2013-01-03 12:05

78 Kruger National Park, www.krugerpark.co.za/Kruger_National_Park


80 “own observations”

81 Valeix et al, 2011, p. 906
The web-camera observations have been achieved through a study performed over five nonconsecutive days in December 2012. Observing two parts of Kruger National Park, Tembe and Orpen as well as another park specialized on African elephants called Addo Elephant Park, or just Addo. The web-cameras are all situated by waterholes at the national parks and are frequently visited by various kinds of larger and smaller mammals as well as birdlife. Through these observations every large mammal activity was recorded with the time and date of the activity. Through combining these activities with literature about impacts, linkages can be made between them. This was analyzed through images via Google Earth, This was to find patterns of trampling for example.

This method was created because of its possible contribution to define zoogeomorphological activities and impacts, that are now missing in current literature about similar subjects. Zoogeomorphology is a narrow discipline and therefore assessments and classifications have to be done in order to make oneself understood, and to help further studies. Furthermore, the studies that have been undertaken with a zoogeomorphological perspective mainly focus on rodents. Bert Eriksson’s study about zoogeomorphological impacts by rodents shows just how important it is to conduct studies at location. Nevertheless it is also evident that photos taken by people or satellite have also been proven as a functioning method to provide evidence for research. Moreover, photos of various impacts that can be seen and maps of areas also give a wide range of information which transcends other obstacles like language. Bert Eriksson uses photos as a way to enhance the understanding of the actual impacts from these activities. Most evident is the degradation of terraces and Azorella-covered risers. Here rodents have dug paths through the Azorella-covered risers, actively killing vegetation.

3.1 Create empirical assessments of zoogeomorphological activities and classify various versions of impacts as described in literature

The articles used have all been chosen with forethought. Considering geomorphology being a subject still not well known all articles have been chosen depending heavily on their age. Most articles used are published after 2007 with a few exceptions. Zoogeomorphology as a discipline is still going through a positive change in the amount of articles published and the amount of studies being done, aiming towards animal impact on landscape.

Zoogeomorphology is an even narrower discipline thus making it a difficult task to find various sources on the subject. Interestingly, most articles and books describe zoogeomorphological activities and impacts although not naming it zoogeomorphology. Instead it is often a sub-part of biogeomorphology or a description of animal behavior in biological or ecological articles.

First, choosing sources that are updated as close to the present as possible is important, because they will be the most correct in terms of peer-reviewing. That is because more people will have previous knowledge of said discipline. Secondly, to classify the various impacts of these activities, literature used have been based on classifications made by Butler, because this is one of the earliest sources which describes zoogeomorphology. Butler is also cited in

82 Bert Eriksson 2011, p.45
83 Ibid, p.45
many other articles on the same matter even though the objects and subjects of the zoogeomorphological articles vary. To create the empirical assessments of zoogeomorphological activities various kinds of literature defining, or describing, geo-, bio- and zoogeomorphology has been read.

3.2 To assess and map visible impacts through photos and Google Earth
As already briefly described, photos are valuable when describing activities and their impacts. Therefore Google Earth has been used to assess the impacts by animal activity on a large scale. It provides an aerial view which helps determining distance as well as the size of features that cannot be measured from the single view through web camera observations. Google Earth also contributes to an extra dimension when it comes to scale, it allows a broader scope making it possible to view landscape close up to overlooking a whole continent. The pictures below are screen shots from Google Earth; they visualize how an area can be observed different depending on scope.

Figure 1. Two screen captions of Tembe National Park through Google Earth, 2012-12-13

Pictures like these give another dimension to other observations and photos on ground level, it makes it possible to trace trampling patterns like shown in picture number one. In the left corner of picture number two one can also see a feature that differs from the rest of the picture. With the aid of these kinds of photos one can determine size and distance which could not have been done without them. These photos are screen shots taken simultaneously at the same time as the observations. Screen shots such as these will be used later, to aid in presenting results.

3.3 To assess and classify impacts on landscape through web-camera observations
The visible physical impacts have been assessed and classified through web camera observations from the 5th to the 13th of December 2012. The web cameras are located at three different locations where one, Addo Elephant Park, is a park explicitly for elephants. The other locations have a variety of animals. The web-camera observations have been accomplished using live broadcasts via web sites. These web sites are broadcasting from
sunrise to sunset, but because they do not provide infrared or artificial light at the locations, animal sights cannot be used for observations at night. These three web cameras have been under observation for five non-consecutive days; 5th - 6th - 7th - 8th and 13th of December 2012. On the 5th the Addo webcam was malfunctioning and the webcam at Tembe displayed rough weather and no movement. Orpen was functioning between 07:00 am to 12:00 pm.

When observing the web cameras they were all displayed on one screen and notes were taken throughout the observations, when activities showed visible impacts on landscape and landscape processes screenshots were taken. The web pages states that most animal activity occurs between 11:00 am and 15:00 pm, although the observations during this study spanned between 08:00 am and 16:00 pm during these five days. Considering that there are no chances of steering the web-cameras some activities and impacts have been lost, due to web camera movement and sometimes malfunction. To observe more than one camera simultaneously, as done in this study, is recommended.

4. RESULTS

Below results of this study are presented, showing observed activities and impacts by large mammals on landscape and landscape processes. Throughout the observations none of the activities or impacts have been quantified, as in studies by Butler, as discussed above, instead the study aims to classify them. This was done in order to assess whether it is of value to study them through a geographical perspective. To present some of the results screen shots have been taken whilst observing web-cameras or using Google Earth. The screen shots are taken whilst the web-cameras display an interesting activity, below each picture a description of the activity and the name of the park will be presented.

The results bring forth not only the outcome of observing mammal activity. It also visualizes current literature on the subject and shows a complete lack of geographical studies, which focuses on large mammal landscape impacts. The results also show that woman researchers and scholars are represented throughout biogeomorphological studies which borders towards geography and zoogeomorphology. This study show results that are evidence enough for the method used to be assessed as reliable when conducting similar research.

Whilst observing animal activity it was apparent that there were different herds of elephants. This was impossible to tell when observing other animals. Elephant herds are divided in female and male groups. The female groups observed had small baby elephants with them and they were also in larger groups. Male elephants were distinguishable because the herds were smaller and they spread out more when wallowing. Another undisputable feature was the presence of sometimes visible genitalia on male elephants.
These two pictures clearly show two various herds, one female and one male. The first picture is of a female herd with a very small baby elephant. The second picture is of two male elephants trying to push each other away from a wallow. When elephants play or fight each other like this, it is a good time to define if the elephants are male or female. Not once during observations did any of the female elephants fight or push each other, but another clear evidence for male elephants is that their genitalia hangs out during, what seems like, harmless arguments, like the fight on the screen shot. No explanation for this has been found through literature used in this study.

4.1 The empirical assessments of zoogeomorphological activities and classification of various versions of impacts described in literature

Zoogeomorphology is a narrow field of study, thus most information which is not strictly zoogeomorphological is found in literature aimed at biology or geomorphology. It is important to bring forth literature, like books from David Butler and L. A Naylor, that is concentrated and specialized at a zoogeomorphological perspective. Recently geological articles show a turn to describing significant zoogeomorphological changes in landscape features. One example is Bert Eriksson’s thesis, which shows clear landscape impacts from animal activity. Even though that particular study is focused on rodents, the fact that animals alter landscape is evidence enough for their importance in any further studies. Especially geographical studies disregard the importance of animal zoogeomorphological activities and their impacts on landscape, that not implying that it is unmentioned throughout all studies.

There are three results from this literature study. The first is that zoogeomorphology is a quite narrow area of interest. Most sources even using the term zoogeomorphology are from after the year 2002, with Butler being the odd one out with his book from 1995. Most studies use the same sources quoting each other. This is evidence for the narrowness of this particular interest. Most former studies are founded within a biological, ecological or geomorphological area of study. Finding geographical studies about animal activities and impacts without the
human activities and impacts being evaluated foremost, have in this study turned out to be impossible.

Secondly it has been easier to use research and studies by woman authors than normal, which has been an interesting feature, otherwise authors who are men has been frequently over represented in Geographical and Geological studies, books and articles. Instead, in studies about zoogeomorphology there are often women authors involved. These are for example Larissa Naylor\textsuperscript{84}, Carol Sawyer\textsuperscript{85}, Heather Viles\textsuperscript{86} and Bindi Thomas\textsuperscript{87}. In geographical studies men are over represented, women authors are often focused on gender and woman issues concerning geography.\textsuperscript{88} To find women in biogeomorphic and zoogeomorphological studies have been easier, although, women authors are still fewer than their male colleagues. In this study six women authors and co-authors have been read and cited, all of whom have contributed greatly to the understanding of biogeomorphology and zoogeomorphology.

Third, the last result of the literature part is that there are few studies with a zoogeomorphological view that has been undertaken in any African country. Not one has been found in South Africa where the area of study regarding these current observations has been performed. There are multiple biological, ecological and geomorphological studies performed in national parks but none that is zoogeomorphological as well as focusing on mammals.

### 4.2 Assessment and mapping of visible impacts through Google Earth

Following is a section that will present the results of Google Earth observations. An important result is Google Earth having the possibility to be regarded in three aspects. These are: local, regional and global. Using Google Earth has proven to be a useful method in observing locations of for example waterholes and the parks themselves. Interesting features around certain waterholes like this from Tembe works as a perfect example of why Google Earth should be acknowledged as a powerful tool. How the waterhole is shaped is now very clear as well as the surrounding features like vegetation or the lack of vegetation. Shadows on the ground show where there is a change in elevation and the lighter areas is proof for the ground being trampled and that there are less coarse sand and gravel at these spots. Below in figure 3 there are two pictures of the same feature, one through Google Earth from above and one from a web camera at ground level.

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\textsuperscript{84} Naylor L.A et al 2002  
\textsuperscript{85} C. F Sawyer in Butler 2012  
\textsuperscript{86} Heather Viles 1988  
\textsuperscript{87} Thomas B. et al 2008  
\textsuperscript{88} “own observations”
Figure 3. Features that are seen via Google Earth can get a new dimension whilst observed with web cameras on ground level. Tembe National Park, 2012-12-13 10:44.

With the aid of these images from Google Earth and web cameras it is possible to overlook a large area where a specific feature is located and then observe the same feature up close. Screen shots have been taken whilst observing, the screenshots are used as pictures in this study. Web cameras do not provide any pictures that will be 100% clear because of web camera and animal movements. Although, these screen shots have all been clear enough to be used as photos that show animal activity and landscape impacts. When animal activities and impacts have been assessed and classified these kinds of images turn into some of the most valuable features in the method. Web cameras provide information that cannot be obtained in any other way without actually being on the location itself. Web cameras located at national parks can aid the people working with the parks on a local level, it can help a whole region or country at the regional level and when it is an aid to keep animals alive it most definitely aids on a global level. Evaluating the results of this study by arranging them into the three levels; local, regional and global may work as a gateway between various disciplines when studying such an interdisciplinary subject as zoogeomorphology.

4.3 Assessments and classifications of visible physical impacts on landscape through web-camera observations

This is where most results have been found that profoundly binds all other results together. Physical impacts from animal activity as already described are trampling, digging, geophagy, uprooting, grazing, wallowing and mourning. The results from the web camera observations of each of these activities are presented below.

Trampling was done differently depending on the mammal. Zebras trample in a line where one zebra leads and the others follow. When they stop to graze they always do so in groups standing very close together while slowly moving from patch to patch. Warthogs and water buffalos travel indifferent to each other although also in groups. The groups are spread out and sometimes the buffalos walk next to each other thus not walking in the same tracks. Female elephants always walk after a leader, it does not matter if they are walking for a long distance or just from one wallow to another and they all follow the same path as their leader. Male groups of elephants show some different behavior although the activities are mostly similar. They do travel somewhat together although there is no clear leader, so through these web camera observations it is almost impossible which elephant the other males follow. The animals which show the most digging activities are elephants and warthogs. Zebras were seen scraping their hoofs on the ground, but the digging by warthogs and elephants was more
profound. Warthogs do dig although it is sometimes difficult to see the impacts of the activities because they are so close to the ground. Elephants on the other hand show a significant impact then they are digging, using tusks, feet and trunks to find roots and minerals in the ground. Elephants also dig to throw dirt on their own bodies as well as on other elephants in the group, to cool down and to get rid of annoying insects. This soil movement created by digging is one of the main factors in landscape change by larger mammals.

When animals eat dirt it is called geophagy, they do so to retain vital minerals and salt which they cannot get from their normal food. Below is a picture of an elephant that just picked up some soil from the ground after some digging with her/his trunk.

![Elephant eating soil](image)

*Figure 4. Elephant eating soil, Tembe National Park 2012-12-08 12:23*

Figure 4 shows an elephant clearly putting something in her/his mouth. During the web camera observations the elephant actually performed this task multiple times. It seemed like s/he was sucking on a piece of rock, to later put it down and choose another bit of soil and repeat. This was one of the most obvious cases of geophagy. Other examples were when elephants sprayed mud on their own back and sometimes sprayed it in their own mouths instead.

Uprooting was not seen once throughout the observations this might be due to the absence of trees in the web camera viewings. All animals viewed were grazing at one point or another when observed. As already described zebras were seen grazing close together while other animals stood with some space in between. The size of animals did not have an effect on the area they used to graze. Even though elephants are significantly larger than the other mammals they graze without making significant impacts on their surrounding when observed for this study. Even though elephants are known to graze rather ferociously none of that was observed.

Wallowing is when animals combine grazing, trampling digging and geophagy in one place. It can also be the acts of social behavior where animals interact with each other. A wallow is a spot where these activities are frequently performed. The physical impacts from animal activity like soil movement, trampling, digging, all occur when mammals wallow.
When a herd of water buffalos came down to the waterhole at Orpen, they laid down in the water thus making the water flow over the edges. The water spilled down to the dry wallows close to the waterhole. Later, water buffalos and elephants gathered in those wallows. Wallows work as meeting places for various animals, and it is in the wallows most elephants stay for long periods of time. It seems like elephants use the wallows to socialize, cool off, eat and play. Often elephants gathered in the wallow and only left to drink somewhere else. The elephants later returned to the wallow. It was also in the wallows that many social activities could be seen. It was in the wallows that elephants sprayed mud on each other, where they touched each other with their trunks, and where some small arguments happened between male elephants. When observing animal activity one should make sure that one can observe wallows.

Above one can see a water buffalo wade down in the waterhole. In the second picture water has spilled into dry wallows around the waterhole. This has gathered other water buffalos.

One mammal known for something as special as mourning is elephants. They are known to return to the same spot where another elephant has died or where the bones are left and perform ritual like activities. None were seen on these specific web camera observations but it is of importance for any further studies because the animals do rearrange any bones and remnants, they also sometimes carry them away. Searching for “elephants mourning” on YouTube will provide a multitude of videos on the subject.
While observing animals through web cameras there are many activities that are significant for this study although some are harder to classify in any of the already mentioned classifications above. Below the activity of one particular elephant shows just that.

![Elephant using a tree to scratch herself.](image)

Figure 7. Elephant using a tree to scratch herself. Tembe National Park. 2012-12-05 11:58

Above an elephant is using a tree to scratch herself as she walks by. Activities like this affect landscape in visible ways. At saltlicks and other places elephants can rub themselves on the same tree or rock side until it gets completely polished.

According to the web camera websites most animal activity occurs between 11:00 am and 15:00 pm. The observations took place between 08:00 am and 16:00 pm and although it was sometimes impossible to observe the animals because of the web cameras themselves, it was clear that the times when most animal activity occurred were between 11:00 am and 14:00 pm. The following table was created after all observations were finished. The aim for this table was to visualize when most animal activity was visible on web cameras in this specific research.

<table>
<thead>
<tr>
<th>Time of observation</th>
<th>Number of activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>07:00-08:00</td>
<td>5</td>
</tr>
<tr>
<td>08:00-09:00</td>
<td>0</td>
</tr>
<tr>
<td>09:00-10:00</td>
<td>0</td>
</tr>
<tr>
<td>10:00-11:00</td>
<td>10</td>
</tr>
<tr>
<td>11:00-12:00</td>
<td>40</td>
</tr>
<tr>
<td>12:00-13:00</td>
<td>10</td>
</tr>
<tr>
<td>13:00-14:00</td>
<td>0</td>
</tr>
<tr>
<td>14:00-15:00</td>
<td>0</td>
</tr>
<tr>
<td>15:00-16:00</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 1. South Africa (SA) is on hour behind Sweden so when observations started at 08:00 am in Sweden it was 07:00 am in South Africa, thus a slight change in time references.
All activities combined peaked around mid-day, at 11:30 am-12:00 pm, it was also then there when most species gathered around the waterholes, elephants, zebras, buffalos and warthogs all followed the same pattern. During the observations it was also evident that the activity most performed by elephants, warthogs and buffalos was wallowing, especially in the wallows surrounding the waterhole.

5. DISCUSSION

Zoogeomorphological studies I not a very well know area of study. When combining animals with geographical studies, it is difficult to find other authors and scholars that are doing the same kinds of studies. The title of this research is called ‘A first classification…’, because no other study has been found, researching zoogeomorphological activities and impacts by large mammals, through a geographical perspective. Another important feature of this study was the method, which has also not been found in any already existing study about zoogeomorphological activities and impacts, with said geographical perspective.

Nevertheless it is proven to be of importance to classify animal activities and how the activities impacts landscape and landscape processes. It is clear through observing animals that their impact on landscape and landscape processes is vast. “Zoogeomorpho -logical-“ studies can be seen as neglected in geographical studies today, even though it might seem just, logical, to assess the impacts of animals the same way as human impacts. There are many similarities between humans and animals, such as creating tunnels, to remove soil and place it somewhere else, to use natural resources as the base of nutrition etc. The list can go on and on.

Another interesting fact, when browsing through literature, was the presence of woman authors and scholars. Women are frequently featuring in areas of study where there is a caring focus, or when the area of study is concentrating on living things. It is invigorating to read the voices of women authors and scholars, even though not specifically used in this study for any other purpose than to use female voices. This is because women authors are not frequent in geographical research and studies today. One way of ensuring that there will be more women voices in geographical literature is to cite them in research. In this study it was easy because women are prominent in the literature used, and all authors used in this study are key figures in zoogeomorphological research.

Zoogeomorphology is a subject of its own but through geographical studies, such as this, it seems like a natural method which shows valuable results. Animals and their activities impacts landscape and landscape processes in visible and invisible ways, nonetheless the importance of studying these activities and impacts are often regarded with less importance in studies about geography. This is peculiar because animals and humans live side by side and humans have relied on animals since the beginning of time. To disregard the vital importance of impacts by animal activit is a mistake. By observing larger mammals as well as reading research of animal zoogeomorphological impacts, it is clear that the animals impact landscape and landscape processes. Furthermore, because the impacts must not be immediate they might be disregarded and less valued. When observing large mammals like elephants trampling or
even just standing by a waterhole it is clearly visible how they do compact soil or enhance erosion on the sides of the waterhole. When eroding the sides of the waterhole it is also expanding it making the capacity to hold more water increase.

As mentioned above elephant trails have been the base of when humans design and decide where to place roads. When elephants stand close to the edges of a waterhole they can erode the sides increasing the waterhole making it possible to retain more water. Large mammals can be called ecosystem engineers because their impacts on landscape do not only affect humans but also all other animals living near them. Ecosystem engineering is when animals activities transforms landscape or landscape processes. Therefore the importance to study animal activity and impact should be prioritized in the future.

This study does not aim to quantify any activities because it is the impacts that have a geographical importance. Therefore the study has focused on what kind of activities that animals perform, and how these activities impact on landscape and landscape processes. It has been evident that animal activities impact landscape. It has also been proven that this method is valid when observing animals. The method used can both assess and classify animal activity when wanted, as well as it can aid observation from a different part of the world.

Because the web-cameras cannot be moved or steered by the observer, there will always be a percentage loss of important sightings. Regardless of this loss it is still enough for undisputable observations. When a small baby elephant falls down into the waterhole and has to fight to be able to climb back up, it is impossible to miss how it impacts the edges of the waterhole. Even though this is a five second observation of animal activities, before the camera turns away, it is still evident that that particular activity impacts on landscape.

6. CONCLUSION

To conclude, through this study a theoretical basis of zoogeomorphological activities and impacts, of large mammals, have been classified and assessed. Mammal activity impacts landscape clearly enough to observe via Google Earth and web cameras. The method, developed specifically for this research, is therefore reliable for a study such as this. The focus on African elephants has proven to be of value because activities by elephants are less difficult to describe, assess and classify. The result of this study is that all observable activities impact landscape, and they exacerbate landscape processes. Animal activities and impacts are important for geographical studies and it should be incorporated when possible.
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